Weed Science 2008 56:151–154

Effect of Hairy Nightshade (*Solanum sarrachoides*) Presence on Potato Nematodes, Diseases, and Insect Pests

Rick A. Boydston, Hassan Mojtahedi, Jim M. Crosslin, Charles R. Brown, and Treva Anderson*

Hairy nightshade is a common weed in potato rotations in the western United States. As a close relative of potato, hairy nightshade can host numerous potato nematodes, diseases, and insect pests. Hairy nightshade hosts three common parasitic nematodes of potato, Columbia and northern root-knot nematodes, and stubby root nematode. Tubers of a potato breeding line with roots that are resistant to Columbia root-knot nematode—race 1, were damaged when grown in the presence of hairy nightshade. The weed provided an alternate host for the nematode, which then allowed the nematode to infect susceptible tubers. Stubby root nematodes transmit tobacco rattle virus (TRV), the causal agent for corky ringspot disease (CRS) of potato. CRS disease was maintained in soil when hairy nightshade was present in rotation crops of alfalfa or Scotch spearmint that otherwise eliminated the disease. Hairy nightshade also is a host of potato leaf roll virus (PLRV), which is transmitted by green peach aphids (GPA). GPA preferentially land and readily reproduce on hairy nightshade. Aphid transmission of PLRV from hairy nightshade to potato was four times greater than the virus transmission rate from potato to potato. Integrated management of these potato nematodes, diseases, and insect pests also should include strategies to control hairy nightshade in potato and rotation crops.

Nomenclature: Columbia root-knot nematode—race 1, *Meloidogyne chitwoodi* Golden et al.; green peach aphid, *Myzus persicae* (Sulzer); hairy nightshade, *Solanum sarrachoides* Sendtner SOLSA; northern root-knot nematode, *Meloidogyne hapla* Chitwood, stubby root nematode, *Paratrichodorus allius* Jensen; alfalfa *Medicago sativa* L.; potato, *Solanum tuberosum* L.; Scotch spearmint, *Mentha cardiaca* Baker.

Key words: Alternative hosts, host-parasite interactions, integrated pest management, nematode; virus; weed host, weed-pest interactions.

Integrated pest management includes use of multiple control tactics and the integration of pest biology knowledge and pest interactions into the management system (Buhler et al. 2000). Weeds can serve as alternate hosts for numerous crop pests (Norris 2005). Rotation to nonhost crops is often used to suppress soil-borne pathogens and pests; however, the presence of weeds acting as alternative hosts in these crops can lead to pathogen or pest persistence (Duncan and Noling 1998). Crop pest management should therefore consider the impact of host weeds on pest persistence.

Potato, a member of the nightshade (*Solanaceae*) family, is grown on approximately 460,000 ha in the United States. Three main nightshade species are present in potato rotations in the western United States; hairy nightshade, black nightshade (*Solanum nigrum* L.), and cutleaf nightshade (*Solanum triflorum* Nutt.) (Ogg and Rogers 1989). Hairy nightshade is the most prevalent of the three in irrigated annual cropping systems. It is a summer annual that germinates from mid-April to late summer in the northern United States and produces pea-sized berries, translucent and brownish-green at maturity with 20 to 30 seeds per berry.

Hairy nightshade is a close relative of potato and can host a plethora of potato nematodes, diseases, and insect pests. Hairy nightshade hosts three common potato parasitic nematodes: Columbia root-knot nematode, northern root-knot nematode, and stubby root nematode (Boydston et al. 2004, 2007; Mojtahedi et al. 2003). Hairy nightshade is a host of potato virus Y (PVY), potato virus A (PVA), potato leaf roll virus (PLRV), potato virus X (PVX), tobacco rattle virus (TRV), late blight (*Phytophthora infestans*), black dot (*Collletotrichum coccodes*), and powdery scab (*Spongospora subterranea*) (Alvarez and Srinivasan 2005; Dandurand et al. 2006; Deahl et al. 2005, 2006; Eberlein et al. 1991; Flier et al. 2003; Olanya et al. 2005; Thomas 2002, 2004). Hairy nightshade also hosts two important potato insect pests: the green peach aphid (GPA) and Colorado potato beetle (*Leptinotarsa decemlineata*). Both insects readily feed and reproduce on the plant (Alvarez and Srinivasan 2005; Hornton and Capinera 1990; Xu and Long 1997).

Crop rotation is commonly practiced to reduce nematodes, diseases, and insect pests of potato, but the presence of hairy nightshade and other alternate weed hosts may nullify these benefits of crop rotation. We submit that hairy nightshade control should be considered an important component of IPM in potato not only because of weed-crop competition, but also because of the potential impact this weed has on several important potato pests. Three examples are provided below to demonstrate the contributions of hairy nightshade as an alternate host, to potato crop damage by nematodes, diseases, and insect pests.

Hairy Nightshade Effects on Potato Cultivars Resistant to Columbia Root-Knot Nematode

Weeds affect nematode populations by acting as alternative hosts, and several researchers have emphasized the importance of weed control for management of plant parasitic nematodes (Belair and Parent 1996; Davis and Webster 2005; Riggs 1992; Roberts 1993; Thomas et al. 2005). Columbia root-knot nematode—race 1 (CRKN-1), is the major potato nematode pest in the northwestern United States (Mojtahedi et al. 1994). Root-knot nematodes (*Meloidogyne* spp.) are sedentary endoparasites, requiring a high level of host specialization to feed and reproduce. Second-stage CRKN-1 juveniles feed inside roots of host plants, undergo three molts, and mature as adults within the root. After invading tubers, CRKN-1 females lay eggs, causing bumps on the surface and brown spots on the flesh, rendering the tubers unmarketable. Rotation to nonhost crops, soil fumigation, and use of certain

DOI: 10.1614/WS-07-035.1

* United States Department of Agriculture, Agricultural Research Service, Vegetable and Forage Crops Research, 24106 North Bunn Road, Prosser, WA 99350. Corresponding author's Email: boydston@pars.ars.usda.gov

cover crops are the main methods of managing CRKN-1 in potato rotations.

Currently, researchers are developing potato cultivars resistant to root-knot nematodes for use in IPM programs (Mojtahedi et al. 1995). Two potato breeding lines, PA95B4-67 and PA99N82-4, developed for resistance to Columbia root-knot nematode were highly resistant to CRKN-1 in greenhouse trials (Brown et al. 2006). However, nematode-damaged tubers were occasionally observed on some resistant potato lines in field trials, especially when late-season weeds were present. Numerous weeds and crops are known hosts of CRKN-1, including hairy nightshade (Boydston et al. 2007; O'Bannon et al. 1982; Santo et al. 1980).

To determine the influence of hairy nightshade on the expression of CRKN-1 resistance in potato, field trials were conducted with the two CRKN-1–resistant potato breeding lines grown with and without hairy nightshade in soil containing a natural population of CRKN-1. These plots were maintained so that potatoes were grown in plots with and without hairy nightshade (Boydston et al. 2007). When the resistant potato lines were grown without hairy nightshade in the nematode-infected soil, the final CRKN-1 population in the soil at potato harvest was lower than when hairy nightshade was present. In the absence of hairy nightshade, nematodes were unable to reproduce, feed, and mature within the root system of either potato line, so there were no adult females moving from the potato roots to invade tubers and cause damage.

Grown in the presence of hairy nightshade, 10% of PA95B4-67 tubers were infected and classified as unmarketable culls, whereas there were very few infected PA99N82-4 tubers and no culls. When hairy nightshade was present, nematodes were maintained and reached maturity in the nightshade roots with subsequent invasion and damage of PA95B4-67, but not PA99N82-4 tubers. Therefore, we speculate that the roots of both potato lines are resistant to CRKN-1, and in addition, PA99N82-4 tubers are resistant, whereas PA95B4-67 tubers remain somewhat susceptible to the nematode.

These results demonstrate the impact of weed presence on nematode populations and that weed management should play an integral role in management of plant parasitic nematodes. Furthermore, future selection of nematode resistance in potato breeding lines should include evaluation of both tuber and root resistance.

Hairy Nightshade Effects on Corky Ringspot Disease Persistence

Corky ringspot (CRS) disease causes brown necrotic corky tissue in potato tubers, rendering them unmarketable. Relatively low levels of infected tubers can result in rejection of entire fields by processors or packers. Tobacco rattle virus (TRV) is the causal agent of CRS and is transmitted by the stubby root nematode, a native of western United States. The disease is present in all major potato production regions in the western United States, and is currently managed by suppressing the nematode vector with soil fumigation. Stubby root nematodes are ectoparasitic nematodes with a wide host range, including crops and weeds (Boydston et al. 2004). Tuber feeding by virus-free nematode does not cause significant damage. However, if nematode become viruliferous after feeding on infected roots, then feed on uninfected tubers, the virus is transmitted, resulting in CRS disease development. Stubby root nematodes acquire the virus by feeding on infected roots and the virus is contained in the stylet (feeding tube). The virus is then transmitted to uninfected plants by nematode feeding.

Stubby root nematodes molt about three times a year, and a portion of the virus is lost with each molt if the nematode population is feeding on uninfected roots of poor TRV host plants. Alfalfa and Scotch spearmint can host stubby root nematodes, but rarely serve as TRV hosts. As a result, TRV was greatly diminished or eliminated from the nematode population after several months of feeding on alfalfa or Scotch spearmint in greenhouse trials (Boydston et al. 2004, Mojtahedi et al. 2003). Thus, these crops could be utilized as part of an IPM program to cleanse CRS-infected fields.

Weeds present in alfalfa or Scotch spearmint serve as stubby root nematode and/or TRV hosts, however, nullifying the cleansing effect of growing these crops. In fact, 24 of 37 weed species tested were suitable stubby root nematode hosts, and 11 of these were infected with TRV (Mojtahedi et al. 2003).

Hairy nightshade is both a stubby root nematode and TRV host (Allen and Davis 1982; Boydston et al. 2004; Jensen et al. 1974; Locatelli et al. 1978; Mojtahedi et al. 2003). In a greenhouse study, TRV was maintained in stubby root nematode on a mix of hairy nightshade plants growing with a non-TRV host, alfalfa or Scotch spearmint. When potatoes were grown in the same soil following the hairy nightshade and crop mix, the viruliferous nematode transmitted TRV to the potatoes, resulting in severe tuber damage (Boydston et al. 2004). Prickly lettuce (*Lactuca serriola* L.), green foxtail [*Setaria viridis* (L.) Beauv.], and Powell amaranth (*Amaranthus powellii* S. Wats.) grown in combination with alfalfa or Scotch spearmint were occasionally able to maintain and transmit TRV via the stubby root nematode, but the impact on tuber quality was far less than with hairy nightshade.

TRV could move to uninfected fields through the spread of seed-borne TRV from infected weeds (Cooper and Harrison 1973; Lister and Murant 1967). Hairy nightshade berries tested positive for TRV in studies by Allen and Davis (1982), but those researchers did not test for TRV presence in seed. TRV was primarily confined to hairy nightshade root tissue and rarely detected in berries during subsequent studies (Boydston et al. 2004). In the same study, when seed from infected berries was used to grow hairy nightshade, the seedlings were not infected, making it unlikely that CRS is spread through dispersal of nightshade seed.

Based on these studies, identification and control of stubby root nematode and TRV host weeds should become part of the nonhost crop-rotation plan to reduce CRS incidence.

Hairy Nightshade Effects on Potato Leaf Roll Virus Epidemiology

PLRV, transmitted by colonizing aphids, is one of the most prevalent and damaging potato viruses worldwide (Stevenson et al. 2001). PLRV is restricted to the phloem tissue and causes characteristic leaf rolling and chlorosis, and plant stunting. The virus can cause total crop loss of susceptible potato cultivars, because infection may lead to tubers with speckled or netted, discolored vascular tissue, termed ''net necrosis.'' GPA is the most prevalent and efficient PLRV vector in potato production (Radcliffe 1982). PLRV is

currently managed by using certified seed potatoes, killing host plant sources of the virus, such as volunteer potatoes and other weeds, and monitoring and controlling aphid vectors. In spite of these practices, however, PLRV still prevails and causes substantial tuber damage in potato production.

Hairy nightshade can become infected with PLRV, and GPA prefer this weed host to potatoes (Alvarez and Srinivasan 2005; Thomas 2002). As much as 6% of hairy nightshade plants collected from Idaho potato fields were infected with PLRV (Alvarez and Srinivasan 2005). Winged and wingless GPA numbers were 5- to 10-fold greater on hairy nightshade than on adjacent potato plants in production fields. Subsequent studies by Srinivasan et al. (2006) demonstrated that GPA favored PLRV-infected over noninfected hairy nightshade and potato plants. The authors suggested that olfactory cues are involved in host selection by the aphid.

Hairy nightshade not only acted as a preferred host of GPA, but aphid reproduction was 24% greater on hairy nightshade than on potato (Alvarez and Srinivasan 2005). Additionally, PLRV transmission by GPA from hairy nightshade to potato was 4 times the transmission rate from potato to potato (Alvarez and Srinivasan 2005). Because hairy nightshade can serve as an elevated inoculum source and preferred GPA host, this weed may play a major role in the epidemiology of PLRV in potato production systems. As a result, researchers have recommended inclusion of hairy nightshade control in PLRV and GPA management strategies for seed and commercial potato production (Alvarez and Hutchinson 2005).

Implications for Integrated Pest Management

These findings implicate hairy nightshade as a particularly troublesome weed in potato rotations; its presence may exacerbate the destructive potential of several pests of potato. Hairy nightshade contributes to substantial potato crop damage by nematodes such as CRKN-1, even in resistant cultivars, and reduced crop net worth from diseases caused by viruses, such as TRV and PLRV. Hairy nightshade makes these contributions by maintaining CRKN-1 populations, reservoirs of TRV and PLRV inoculum, and viruliferous vectors such as stubby root nematodes and GPA. Utilizing crop rotation and resistant crop cultivars to suppress nematodes and plant pathogens are desirable IPM strategies; however, poor management of alternate host weeds could contribute to failures using these approaches.

Current potato nematode, disease, and insect pest management practices are focused on the pests and the crop rather than on hairy nightshade. The examples described herein involve a weed closely related to the crop; however, there are numerous examples of weeds not related to a crop hosting nematodes, diseases, and insect pests detrimental to that crop. Therefore, integrated pest management strategies to prevent or minimize crop damage by these types of pests should also include control of alternate host weed species present in the crop and in all rotation crops.

Literature Cited

Allen, T. C. and J. R. Davis. 1982. Distribution of tobacco rattle virus and potato virus X in leaves, roots, and fruits/or seeds of naturally infected weeds. Am. Potato J. 59:149–153.

Alvarez, J. M. and P.J.S. Hutchinson. 2005. Managing nightshade plants to reduce potato viruses and insect vectors. Outlooks Pest Manag. J. 16:249–252.

Alvarez, J. M. and R. Srinivasan. 2005. Evaluation of hairy nightshade as an inoculum source for aphid-mediated transmission of potato leafroll virus. J. Econ. Entomol. 98:1101–1108.

Belair, G. and L. E. Parent. 1996. Using crop rotation to control *Meloidogyne hapla* Chitwoodi and improve marketable carrot yield. Hortscience 31:106–108.

Boydston, R. A., H. Mojtahedi, C. R. Brown, T. Anderson, and E. Riga. 2007. Hairy nightshade undermines resistance of potato breeding lines to Columbia root-knot nematode. Am. J. Potato Res. 84:245–251.

Boydston, R. A., H. Mojtahedi, J. M. Crosslin, P. E. Thomas, T. L. Anderson, and E. Riga. 2004. Evidence for the influence of weeds on corky ringspot persistence in alfalfa and Scotch spearmint rotations. Am. J. Potato Res. 81:215–225.

Brown, C. R., H. Mojtahedi, S. James, R. G. Novy, and S. Love. 2006. Development and evaluation of potato breeding lines with introgressed resistance to Columbia root-knot nematode (*Meloidogyne chitwoodi*). Am. J. Potato Res. 83:1–8.

Buhler, D. D., M. Liebman, and J. J. Obrycki. 2000. Theoretical and practical challenges to an IPM approach to weed management. Weed Sci. 48:274–280.

Cooper, J. I. and B. D. Harrison. 1973. The role of weed hosts and the distribution and activity of vector nematodes in the ecology of tobacco rattle virus. Ann. Appl. Biol. 73:53–66.

Dandurand, L. M., G. R. Knudsen, and C. V. Eberlein. 2006. Susceptibility of five nightshade (*Solanum*) species to *Phytophthora infestans*. Am. J. Potato Res. 83:205–210.

Davis, R. F. and T. M. Webster. 2005. Relative host status of selected weeds and crops for *Meloidogyne incognita* and *Rotylenchuus reniformis*. J. Cotton Sci. 9:41–46.

Deahl, K. L., R. Jones, L. A. Wanner, and A. Plant. 2005. Late blight caused by *Phytophthora infestans* on *Solanum sarrachoides* in northeastern Maine. Plant Dis. 89:435.

Deahl, K. L., R. W. Jones, and F. M. Perez. 2006. Characterization of isolates of *Phytophthora infestans* from four Solanaceous hosts growing in association with late blight-infected commercial potato crops. Hortscience 41:1635–1639.

Duncan, L. W. and J. W. Noling. 1998. Agricultural sustainability and nematode integrated pest management. Pages 251–287 *in* K. R. Barker, G. A. Pederson, and G. L. Windham, eds. Plant and Nematode Interactions. Agronomy Monograph 36. Madison, WI: American Society of Agronomy, Crop Science Society of America, Soil Science Society of America.

Eberlein, C. V., A. W. Barkdoll, and J. R. Davis. 1991. Pathogenicity of *Colletotrichum coccodes* isolates to potato (*Solanum tuberosum*) and two nightshade (Solanum spp.) species. Weed Technol. 5:570–574.

Flier, W. G., G.B.M. Van den Bosch, and L. J. Turkensteen. 2003. Epidemiological importance of *Solanum sisymbriifolium*, *S. nigrum* and *S. dulcamara* as alternative hosts for *Phytophthora infestans*. Plant Pathol. 52:595–603.

Hornton, D. R. and J. L. Capinera. 1990. Host utilization by Colorado potato beetle (Coleptera:Chrysomelidae) in a potato/weed (*Solanum sarrachoides* Sendt.) system. Can. Entomol. 122:113–121.

Jensen, H. J., P. A. Koepsell, and T. C. Allen. 1974. Tobacco rattle virus and nematode vectors in Oregon. Plant Dis. Rep. 58:269–271.

Lister, R. M. and A. F. Murant. 1967. Seed-transmission of nematode-borne viruses. Ann. Appl. Biol. 59:49–62.

Locatelli, E. A., T. C. Allen, P. A. Koepsell, and S. P. Appleby. 1978. Diagnosis of tobacco rattle virus (TRV) and other viruses in weed and rotation crops in potato fields. Am. Potato J. 55:249–257.

Mojtahedi, H., R. A. Boydston, P. E. Thomas, J. M. Crosslin, G. S. Santo, E. Riga, and T. L. Anderson. 2003. Weed hosts of *Paratrichodorus allius* and tobacco rattle virus in the Pacific Northwest. Am. J. Potato Res. 80:379–385.

Mojtahedi, H., C. R. Brown, and G. S. Santo. 1995. Characterization of resistance in a somatic hybrid of *Solanum bulbocastanum* and *S. tuberosum* to *Meloidogyne chitwoodi*. J. Nematol. 27:86–93.

Mojtahedi, H., G. S. Santo, H. Ferris, and V. Williamson. 1994. A new host race of *Meloidogyne chitwoodi* from California. Plant Dis. 78:1010.

Norris, R. F. 2005. Symposium. Ecological bases of interactions between weeds and organisms in other pest categories. Weed Sci. 53:909–913.

O'Bannon, J. H., G. S. Santo, and A. P. Nyczepir. 1982. Host range of the Columbia root-knot nematode, *Meloidogyne chitwoodi*. Plant Dis. 66:1045–1048.

Ogg, A. G. and B. S. Rogers. 1989. Taxonomy, distribution, biology, and control of black nightshade (*Solanum nigrum*) and related species in the United States and Canada. Rev. Weed Sci. 4:25–58.

Olanya, O. M., D. H. Lambert, and A. B. Plant. 2005. Occurrence and cross-infection of *Phytophthora infestans* on hairy nightshade (*Solanum sarrachoides*) and potato (*Solanum tuberosum*) in Maine. Can. J. Plant Pathol. 27:458–460.

Radcliffe, E. B. 1982. Insect pests of potato. Ann. Rev. Entomol. 27:173–204.

Riggs, R. D. 1992. Host range. Pages 107–114 *in* R. D. Riggs and J. A. Wrather, eds. Biology and Management of the Soybean Cyst Nematode. St. Paul, MN: American Phytopathological Society Press.

Roberts, P. A. 1993. The future of nematology: Integration of new and improved management strategies. J. Nematol. 25:383–394.
Santo, G. S., J. H. O'Bannon, A. M. Finley, and A. M. Golden. 1980. Occurrence and host range of a new root-knot nematode (*Meloidogyne chitwoodi*) in the Pacific Northwest. Plant Dis. 64:951–952.
Srinivasan, R., J. M. Alvarez, S. D. Eigenbrode, and N. A. Bosque-Perez. 2006. Influence of hairy nightshade (*Solanum sarrachoides* Sendtner) and *potato leafroll virus* (Luteoviridae: *Polerovirus*) on the host preference of *Myzus persicae* (Sulzer) (Homoptera: Aphididae). Environ. Entomol. 35:546–553.
Stevenson, W. R., R. Loria, G. D. Franc, and D. P. Weingartner. 2001. Compendium of Potato Diseases. 2nd ed. St. Paul, MN: American Phytopathological Society Press. 144 p.
Thomas, P. E. 2002. First report of *Solanum sarrachoides* (hairy nightshade) as an important host of potato leafroll virus. Plant Dis. 86:559.
Thomas, P. E. 2004. Black and hairy nightshade, the first weedy hosts of potato virus A in the United States. Plant Dis. 88:905.
Thomas, S. H., J. Schroeder, and L. W. Murray. 2005. Symposium. The role of weeds in nematode management. Weed Sci. 53:923–928.
Xu, G. and G. Long. 1997. Host-plant phenology and Colorado potato beetle (Coleoptera: *Chrysomelidae*) population trends in eastern Washington. Environ. Entomol. 26:61–66.

Received February 12, 2007, and approved May 30, 2007.